REMARKS/ARGUMENTS

The Non-Final Office Action mailed on February 9, 2006, has been reviewed and the comments of the Patent and Trademark Office duly considered. Prior to this paper, claims 1-14 were pending in the present application. By this amendment, applicants do not cancel or add any claims but claim 8 has been amended to better convey the substance of the invention. Therefore, claims 1-14 are now pending in the present application.

Indication of Allowable Subject Matter

Applicants would like to reiterate their thanks to Examiner Jenkins for the indication that claims 1-7 are allowed.

Claim Rejections Under 35 U.S.C. §112, First Paragraph

In the Office Action, claims 8-14 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement.

Specifically, the Examiner asserts that maintaining the pressure of xenon at a pressure above its critical pressure would not result in a density that would equate that of, for example, stainless steel, which is greater than 7.8g/cc.

Applicants respectfully traverse the rejection for at least the following reasons:

A xenon density of 7.89 g/cm^3 is achievable with state-of-the-art equipment

In their specification (Page 19, lines 4 ff.), applicants described a theoretical method derived from the virial equation of state for non-ideal gases to determine the pressure to which xenon must be raised in order to maintain an alumina body of density 3.965 g/cm^3 buoyant at 700K.

To obviate redundancy, applicants deliberately omitted to provide a similar explanation for a stainless steel body of density 7.890 g/cm^3 in the conviction that a person of ordinary skill in the art would inherently have recourse to the same method.

Following is a description of this theoretical method for the 316L stainless steel body described in applicants' specification (Page 12, lines 5-7).

The initial pressure to which a fluid medium of composition Xe: 50% - CO_2: 50% must be subjected in order to make the stainless steel green body buoyant at the outset of the binder removal and sintering process, i.e. when the temperature is about 300K, is yielded by equation (12) (Specification, page 18, antepenultimate line) in which the values for the molar mass, van der Waals constants and second virial coefficient at 300K for the fluid medium of this particular composition are unchanged from those provided in the specification.

$P\ (Xe50CO_2, 300K) = 8.31451 * 300 * ((0.0876514 / 5.369\ 10^3) - (-1.275\ 10^{-4}))^{-1}$
$\approx 19{,}563{,}553 Pa \approx 19.5 MPa$

Upon maintaining the stainless steel green body for a sufficient time at 700K, the organic binder will have been substantially extracted and the original green body will have acquired an open porosity structure and a true density substantially equal to that of stainless steel, i.e. about 7.890 g/cm^3.

Using the already found (Specification, page 20, line 10) value for the second virial coefficient for the fluid medium at 700K, equation (12) yields the pressure required to maintain buoyancy:

P ($Xe50CO_2$, 700K) = 8.31451 * 700 * ((0.0876514 / 7.890 10^3) – (-2.023087478 10^{-5}))$^{-1}$ ≈ 185,709,877Pa ≈ 185.7MPa

For the transition to pure xenon, using the calculated second virial coefficient for pure xenon at 700K, equation (12) again yields the pressure required to maintain buoyancy.

P (Xe, 700K) = 8.31451 * 700 * ((0.13129300 / 7.890 10^3) – (-2.047475121 10^{-5}))$^{-1}$ ≈ 156,813,375Pa ≈ 156.8MPa

At this pressure, the porous stainless steel body will be buoyant in pure xenon at 700K.

Stainless steel is commonly sintered to near-full density at about 1300-1350°C (1573-1623K). The temperature range within which full densification can occur depends on the purity and morphology of the original particulate material. For example, it is well known that reducing the particle size of a powder lowers its sintering temperature.

Practically speaking, when the stainless steel body reaches 927°C (1200K), it will generally already have shrunk to the extent where it has sufficient tensile strength to withstand both gravitational as well as frictional forces, especially when the sintering process is conducted in a HIP vessel. Thus it would be pointless, and in fact wasteful, to attempt maintaining buoyancy all the way to the end temperature at which full or near-full densification occurs.

The second virial coefficient of xenon at 1200K is

B, m^3/mol @ 1200K = 5.155999749 10^{-5} – (0.4192535469 / (8.31451 * 1200)) = 9.539727414 10^{-6}

Using this value in equation (12) yields the corresponding pressure needed to achieve buoyancy:

$$P\,(Xe,\,1200K) = 8.31451 * 1200 * ((0.131293 / 7.890\ 10^{3}) - (9.539727414\ 10^{-6}))^{-1} \approx 1405130067Pa \approx 1.4GPa$$

As indicated in the specification (page 13, lines 4-10), HIP systems capable of operating at such high pressure and temperature are already in the market and new ones, capable of ever higher temperatures and pressures will undoubtedly be developed in the future.

Thus, the ability to maintain a stainless steel body buoyant until it has reached a tensile strength sufficient to withstand deformation by gravitational and frictional forces, is clearly achievable with state-of-the-art equipment.

The virial equation of state for non-ideal gases, though deficient at high temperatures, is adequate for processing stainless steel green bodies in accordance with the present invention

The virial equation of state has a sound theoretical basis. It can be made as accurate as desired by keeping more terms in the virial expansion. In applicants' specification only the second virial coefficient has been retained. Consequently, the function of pressure versus temperature (equation 12) is restricted in its use because it admits a vertical asymptote at a particular temperature, T_0, at which the corresponding pressure, P_0, becomes infinite.

The vertical asymptote can be found by replacing equation (10) in equation (12), yielding:

$$P = \frac{RT}{\frac{M}{\rho} - b + \frac{a}{RT}}$$

Equating the denominator to 0 yields temperature T_0

$$T_0 = \frac{-a}{R\left(\frac{M}{\rho} - b\right)}$$

In the case of the 316L stainless steel green body processed in pure xenon, we get

T_0 (316L, Xe) = -0.4192535469/8.31451((0.131293/7,890)-5.155999749 10^{-5}) ≈ 1444K

According to the virial equation of state, at this temperature the corresponding pressure P_0 becomes infinite, clearly a physical impossibility. Thus, well before the temperature in the HIP vessel reaches 1444K, the virial equation of state becomes useless and other mathematical models, more representative of reality must be sought. Such models will undoubtedly be generated once more research in the field of gases at high pressure and temperature has taken place.

In summary, the shortcomings of the virial equation of state do not preclude the practical application of the present invention.

CONCLUSION

For all of the above reasons, applicants submit that the present application is now in condition for allowance, which action they respectfully solicit.

CONDITIONAL REQUEST FOR CONSTRUCTIVE ASSISTANCE

Applicants have amended claim 8 of this application so that it more appropriately reflects the substance of their invention. If, for any reason this application is not believed to be in full condition for allowance, applicants respectfully request the constructive assistance of the Examiner pursuant to MPEP § 2173.02 and § 707.07(j) in order that the undersigned may place this application in allowable condition as soon as possible and without the need for further proceedings.

Respectfully submitted this 26th day of April, 2006 by

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Certificate of Mailing

The undersigned, Romain Louis BILLIET, first named inventor in Application No. 10/720,613, hereby certifies that this correspondence will be deposited with the Malaysian Postal Services (Pos Malaysia) as Express Mail Service (EMS) addressed to Mail Stop NON-FEE AMENDMENT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, USA, on Wednesday, April 26, 2006.

April 26, 2006 --

Romain L. Billiet, First Applicant